HYDROLOGY

Precipitation

The average annual precipitation for the basin is about 46.0 inches (MDNR 1984). The average annual gaged precipitation near the center of the basin at Marble Hill, Missouri is 44.4 inches (Figure 2). The basin, although situated in the wettest part of the state, receives the least amount of statewide summer rainfall, usually less than 11.0 inches during the high evapotranspirational months of June, July and August. The maximum expected precipitation for 1-, 4- and 10-day storm events with two-year recurrence intervals are 3.5, 4.5 and 6.0 inches, respectively.

Maximum expected precipitation for the same storm events with 25-year recurrence intervals are 6.0, 8.5 and 11.0 inches. In May 1973, the basin received 11.5 inches of rainfall during a severe 15-hour storm which did not establish any new discharge or stage records. Snowfall averages about 9.0 inches per year.

The average annual runoff is 16.0 inches. However, when considering only precipitation and runoff amounts, perhaps as much as 35 percent of the annual average precipitation eventually appears in channels as streamflow and about 65 percent (30 inches) is lost to evapotranspiration (MDNR 1984).

U.S.G.S. Gaging Stations

One U.S.Geological Survey gage station (No. 07-0210.00) is currently operating in the basin. This continuous, stage-recording station is located on the lower Castor River at RM 5.7 on the left downstream side of the State Highway 51 bridge near Zalma, Missouri (Figure gs). The period of record is from January 1920 to the current year. The location of the gage measures most of the discharge exiting the Castor River watershed, which represents, however, only 35 percent of the total area of the basin.

The topographic and hydrologic features of the subbasins and watersheds within the Headwater Diversion Basin are quite similar. Gage information from the Castor River station at Zalma can be adjusted by watershed size and directly transposed to ungaged sites. Possible exceptions to the application of transposed gage records might be the low relief watersheds of Hubble and Ramsey creeks. For example, the streamflow and stormwater-runoff records from the Zalma gage were transposed (by direct watershed area ratios) to provide the critical engineering design specifications for a proposed 7,500-acre reservoir project in the Whitewater River subbasin (Lemons 1989).

During most of the 1960's, six USGS low flow, partial recording gage stations were operated at various locations on Castor and Whitewater Rivers, Crooked Creek and the Diversion Channel (Table 6). These gages provided only low flow information and are currently inactive.

Streamflow Characteristics

The average annual discharge of the Castor River at the Zalma gage is 517 cubic feet per second (cfs). The median flow (greater or lesser discharges 50% of the time) is 183 cfs. The minimum, average and maximum annual hydrographs (Figure 3) and a mean daily flow duration curve (Figure 4) have been prepared from the gage records. Partial recording gages have provided low flow estimates of the magnitude and frequency of 7-day Q values (low flow discharges) for each of the four major tributaries in the basin (Table 7). The partial gages have also provided base flow depletion characteristics for the summer recession flows associated with the same tributaries (Table 6).

Inspection of the available gage records indicate that stream flows, particularly low flows, throughout the entire basin are quite stable and exhibit little variability in annual or year-to-year discharges. Evidence of good basin-wide flow conditions include: Minimum low flow gage records of 10 to 20 cfs in fifth and sixth order stream channels; no gage records of zero flow; 7-day Q10 low flows usually exceeding 10 cfs; 7-day Q30 low flows exceeding 5 cfs; low slope indexes of about 2; low base flow summer recession rates and a low 90:10 ratio of 18 to 1 at the Zalma gage.

Favorable precipitation, evaporation and runoff conditions, combined with the high storage capacity of the soluble subsurface chert and unconsolidated alluvium, produces a natural groundwater supply that sustains stable base flows. The result is a high incidence of stream permanency which produces fewer stress factors that can affect aquatic communities. The favorable hydrological environment is evidenced by the diverse assemblage of fishes and macroinvertebrates that currently occupies the basin.

Dam and Hydropower Influences

Only one small mainstem dam currently exists in the basin. A mill dam at Bollinger Mill State Park (historical mill and covered bridge) spans the Whitewater River at RM 16.0. The pool behind the 6-ft tall concrete and timber dam has filled with gravel and no longer provides storage capacity. The entire top of the dam now functions as the primary spillway, but some flow can still be diverted through the mill to operate machinery. The plunge pool and downstream channel are stable. Moderate storm events frequently flood the dam. However, during normal flows the dam inhibits the upstream movement of fish.

On the Castor River at RM 53.8, a 5-ft tall steel reinforced concrete dam with its western abutment completely washed out remains intact in the river channel. The dam, which was once part of the Daniel Boone Lodge (private development), failed immediately after completion nearly 60 years ago. The dam now functions as an effective wing dike with its bottom and eastern abutment firmly anchored in bedrock. After 60 years, the new downstream channel (displaced around the west side of the dam) has apparently stabilized. The original river channel now functions as an overflow channel. The site is entirely within the boundaries of the Amidon Memorial Conservation Area (MDC). Any attempt to remove the old dam would most probably have serious consequences on channel hydraulics and aquatic habitats above and below the site.

On the Diversion Channel at RM 20.8, a well engineered and maintained USACOE grade control

structure functions as a 10-ft high falls that can prevent the upstream movement of fish into the Castor River subbasin. Backwater from the Mississippi River completely inundates the top of the structure (known locally as the Blockhole) at a river stage of 35 ft (340 ft NGVD) on the USACOE Cape Girardeau gage. However, strong swimming fish can probably pass over the angled lip of the rock structure at a Mississippi River flood stage of 32 ft. During normal flood years (14 of the last 21 years) Mississippi River flood stages exceeding 32 ft can be expected 42 percent of the time during April and May and 34 percent of the time March through June. The duration of a typical spring flood is 28 days. The less frequent fall floods last about 9 days.

A proposed 7,680-acre recreational lake on the mainstems of the Whitewater River and Little Whitewater Creek (Figure 2-A in Appendix A) was jointly suggested by the Cape Girardeau and Bollinger county commissions in 1987. A \$100,000 geology/ engineering/economics feasibility study (Lemons 1989) that supported the proposed lake project was completed in 1989. The lake proposal became inactive in 1991 after the Bollinger County Commission refused to include a one cent sales tax issue on the November ballot that would help fund the \$73 million project. Local public opinion regarding the lake was sharply divided between positive in the business and urban communities to adamantly negative in the rural community. The Department did not take a position and the Missouri Chapter of the American Fisheries Society, through a 1990 resolution, opposed the lake development. The lake would have flooded parts of the Old Plantation AC, Maintz CA and about 36 miles of permanent streams (Table 9).

Figure 2. Monthly maximum (20% chance), minimum (20% chance), and average precipitation at Marble Hill, Missouri for the period of record (1951-1980).

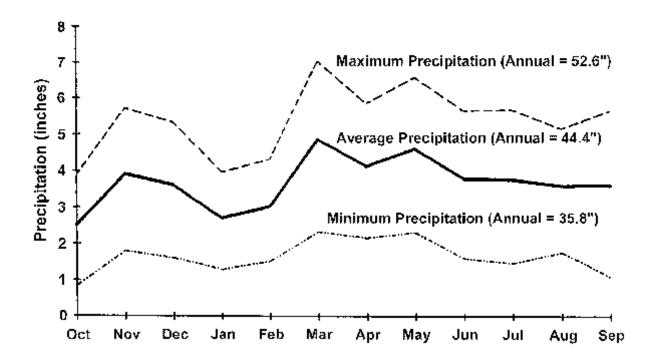


Figure 3. Monthly maximum, minimum, and average stream flow at the Castor River Zalma gage station for the period of record (1920-1990).

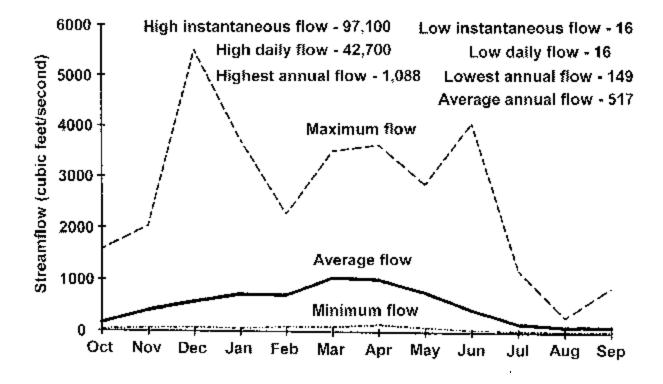
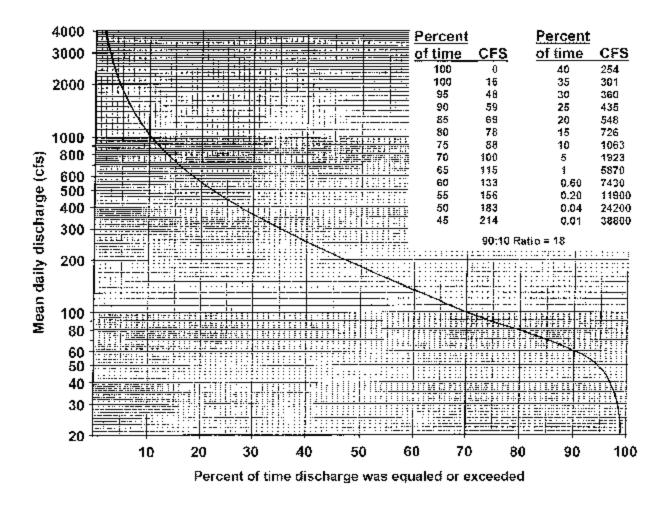
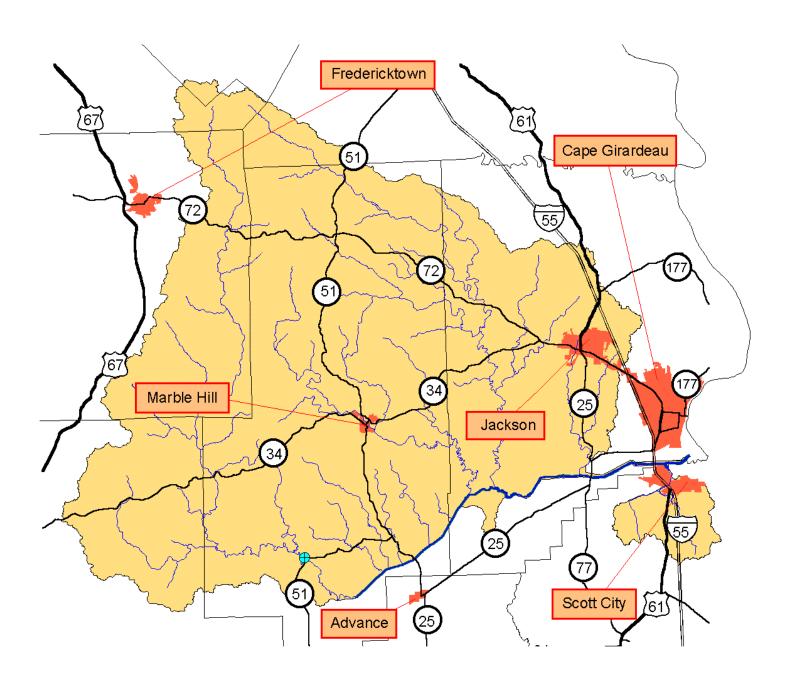


Figure 4. Flow duration curve, Castor River at the Zalma gage, 1922 through 1992, Headwater Diversion basin, Missouri.









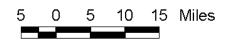


Figure gs. Gaging station location in the Headwater Diversion Basin, in Missouri.

Table 6. Base-flow (cfs) recession characteristics. Average rate of depletion of base flow during May through October drought periods, Headwater Diversion Basin, Missouri. From Skelton (1970)

CACENO	STREAM	SITE	PERIOD OF MEASURED		TIME, IN DAYS, OF DROUGHT					
GAGE NO.			ANALYSIS	LOW FLOW	0*	10	20	30	40	
**7-0218.00	Diversion Channel	Allenville	1951-67	44.0	120.0	80.0	55.0	41.0	30.0	
**7-0209.50	Castor River	Cascade	1967-71	23.8						
7-0210.00	Castor River	Zalma	1922-67	16.0	65.0	45.0	33.0	25.0	19.0	
**7-0216.00	Whitewater River	Whitewater	1961-67	16.0	30.0	19.0	13.0	9.0	6.5	
**7-0214.00	Whitewater River	Millersville	1961-67	11.0	20.0	15.0	11.0	8.5	6.2	
**7-0211.50	Crooked Creek	Marble Hill	1961-67	2.1	3.5	1.6	0.8	0.5	0.2	
**7-0213.00	Crooked Creek	Highway U	1962-64	1.1						

^{*=}Upper limit of base flow, no surface runoff.

Table 7. Estimated magnitude and frequency of annual low flows, Headwater Diversion Basin, Missouri. (Modified from MDNR (1984)

GAGE NO.	STREAM	SITE	PERIOD OF ANALYSIS	7-DAY LOW FLOW (CFS) FOR INDICATED RECURRENCE INTERVAL (YEARS)					SLOPE INDEX
				Q2	Q5	Q10	Q20	Q30	(Q2/Q20)
7-0218.00	Diversion Channel	Allenville	1951-69	78.0	55.0	42.0	32.0	29.7	2.4
7-0210.00	Castor River	Zalma	1920-81	46.0	34.0	27.0	21.6	19.0	2.1
7-0216.00	Whitewater River	Whitewater	1961-67	19.0	13.0	10.0	7.6	6.5	2.5
7-0214.00	Whitewater River	Millersville	1961-69	14.0	10.3	8.2	6.5	5.7	2.2
7-0211.50	Crooked Creek	Marble Hill	1961-69	2.3	1.6	0.8	0.5	0.4	4.6

^{**=}Low flow partial - recording station provides only low flow data.

Table 9. Stream resources, by watershed, that would be flooded by a proposed 7,680-acre Cape Girardeau/Bollinger County recreational lake. (conservation pool at 480 NGVD)

	Whitewat	er River	Litt Whitewa		Lake Basin Totals		
Order	No. Reaches	No. Miles	No. Reaches	No. Miles	No. Reaches	No. Miles	
5	1	0.3	1	8.4	2	8.7	
4	2	19.8			2	19.8	
3	3	4.9	2	3.8	5	8.7	
2	9	3.0	5	3.3	14	6.3	
1	38	18.0	34	12.2	72	30.2	
	53	46.0	42	27.7	95	73.7	

Lake Girardeau, a 162-acre MDC public fishing area, is the largest lake in the basin. Forty additional privately owned small lakes that total 856 acres are scattered throughout the lower elevations in the basin (MDNR 1984).